AgriGrid

A business model concept for next-generation mini-grids in Africa

The EnAccess Foundation

ANKA MADAGASCAR

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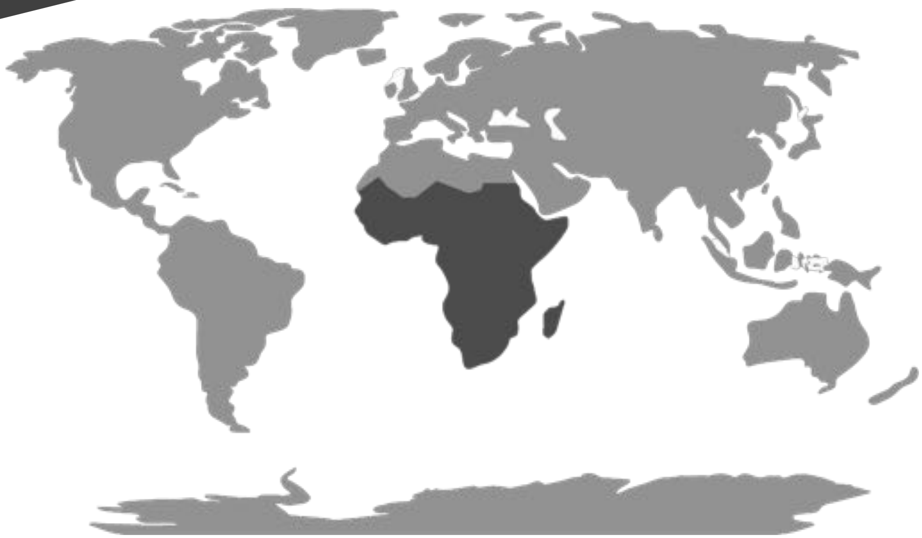
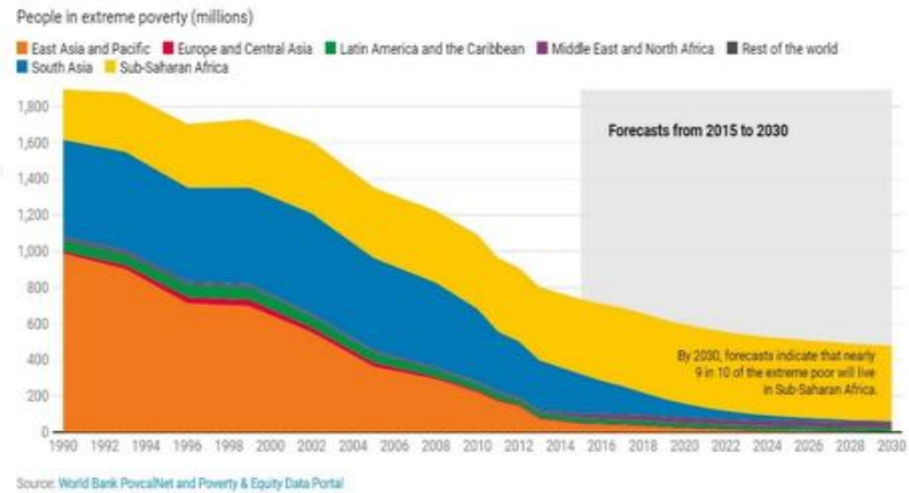
CONTEXT

Poverty, energy, and agriculture dynamics in Sub-Saharan Africa

The majority of the world's poor lives in rural sub-Saharan Africa





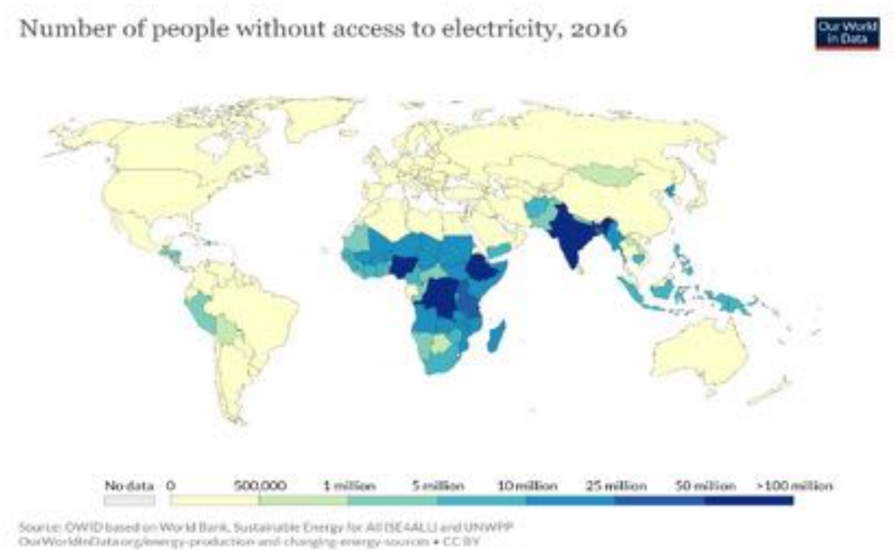
Sources: www.un.org/sustainabledevelopment ; http://blogs.worldbank.org/

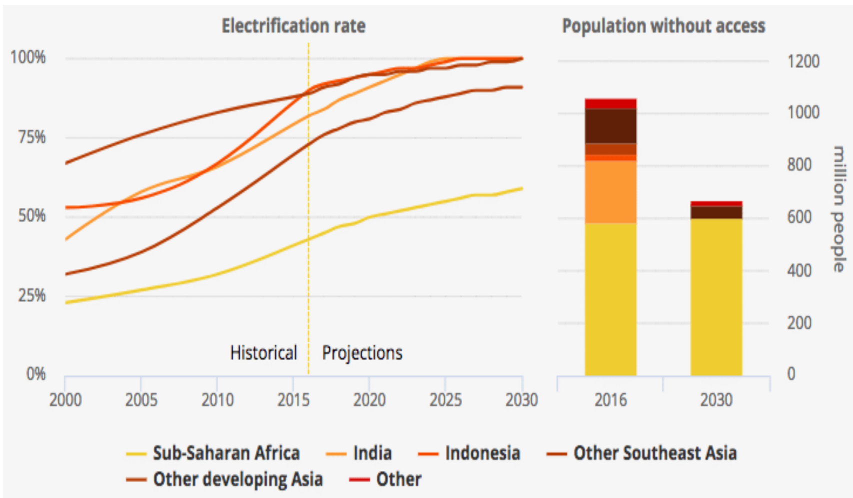
56% of the people currently living in extreme poverty are in Sub-Saharan Africa

70% of the world's poor population live in rural Africa

~90% extremely poor people will live in Sub-Saharan Africa, by 2030

55% of households in sub-Saharan Africa lack electricity access





In 2019

An estimated **573 million people in Sub-Saharan Africa** lack access to electricity

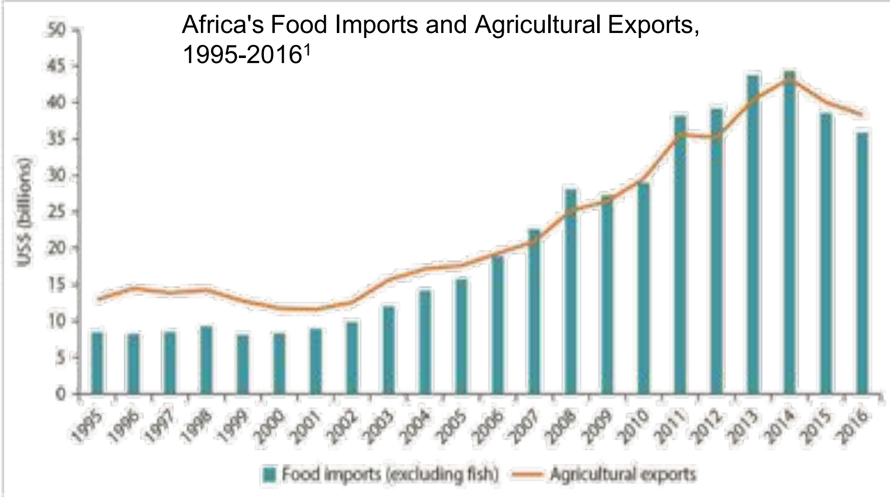
In 2030

Without dramatic changes in energy access, **600 million people in Africa** will lack access to electricity

Sources: www.un.org/sustainabledevelopment / http://blogs.worldbank.org/

Africa imports USD 50 billion of food each year

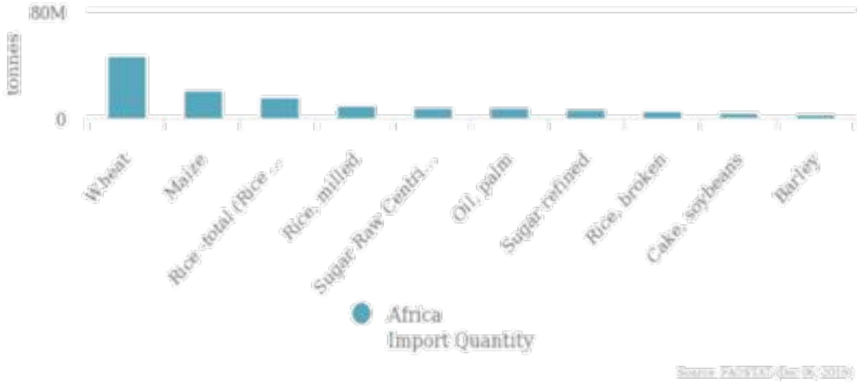
Africa's Food Imports and Agricultural Exports, 1995-2016[1]



The food import bill for sub-Saharan Africa is expected to be **USD 48.7 billion in 2019**, up 3.8% from USD 46.9 billion in 2018[5]

Food imports in Africa are expected to grow to over **USD 110 billion by 2025[6]**

Top 10 imported food commodities in Africa in 2017



Consumer demand for food products in Africa will exceed **USD 700 billion by 2030**

Sources:
[1] FAO STAT
[2] http://algeriebusiness.com/agroalimentaire/sub-saharan-africa-food-imports-will-rise-to-48-7-billion-in-2019-fao/
[3] https://www.downtoearth.org.in/news/a-grain-revolution-for-africa-58672
[5] http://algeriebusiness.com/agroalimentaire/sub-saharan-africa-food-imports-will-rise-to-48-7-billion-in-2019-fao/
[6] https://www.afdb.org/en/news-and-events/afdb-discusses-its-strategy-for-africas-agricultural-transformation-16155

Crop yields in Africa are a fraction of global averages

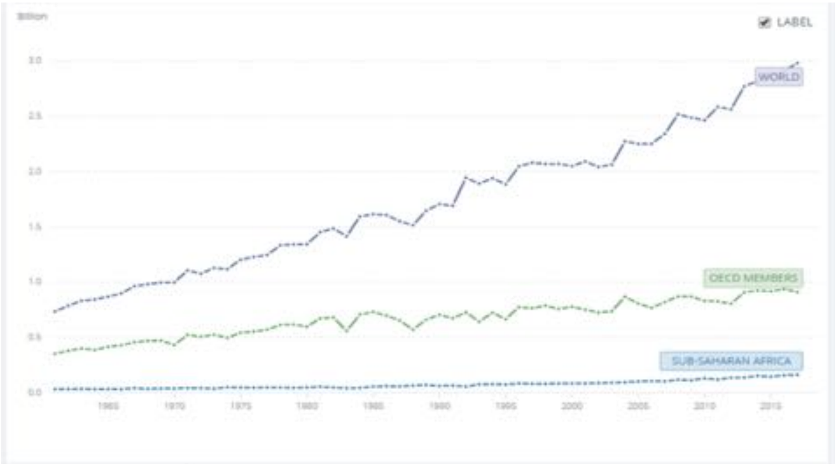
Cereal* yield (kg per hectare) in 2017[1]

Africa has more than 50% of the world's fertile and unused arable land

Average fertilizer use in Africa is 17kg per hectare of arable land, compared with a global average of 135 kg

Agricultural yields are 56% of the international average

Cereal* production (metric tons) - Sub-Saharan Africa, OECD members, World[1]



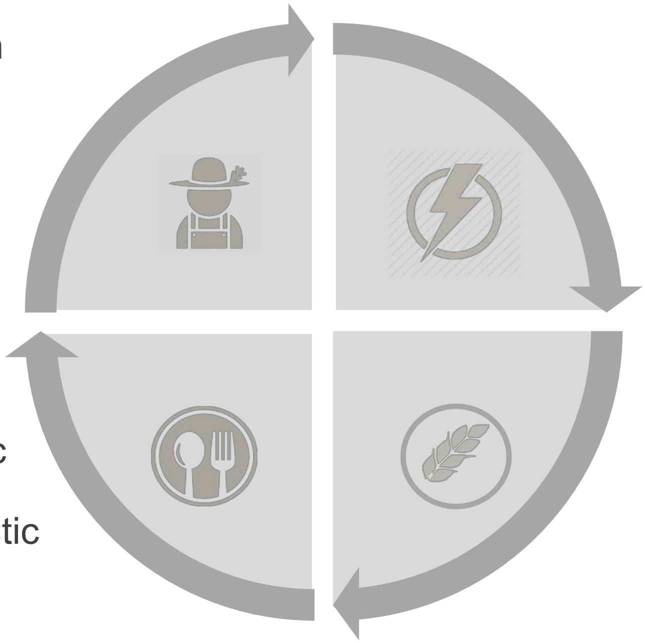
Note:
*Cereal includes wheat, rice, maize, barley, oats, rye, millet, sorghum, buckwheat, and mixed grains

Sources:
[1] Word Bank, https://data.worldbank.org/
[2] MDPI, Raising Crop Productivity in Africa through Intensification, 2017, p1
[3] Abebe Shimeles, Audrey Verdier-Chouchane, Amadou Boly, Introduction: Understanding the Challenges of the Agricultural Sector in Sub-Saharan Africa, 2018, p1

These challenges are seen throughout sub-Saharan Africa

Rural areas remain economically disadvantaged

There is a major need for modern and decentralized energy solutions



Growth in domestic food demand is outstripping domestic supply

Domestic agricultural systems require transformation

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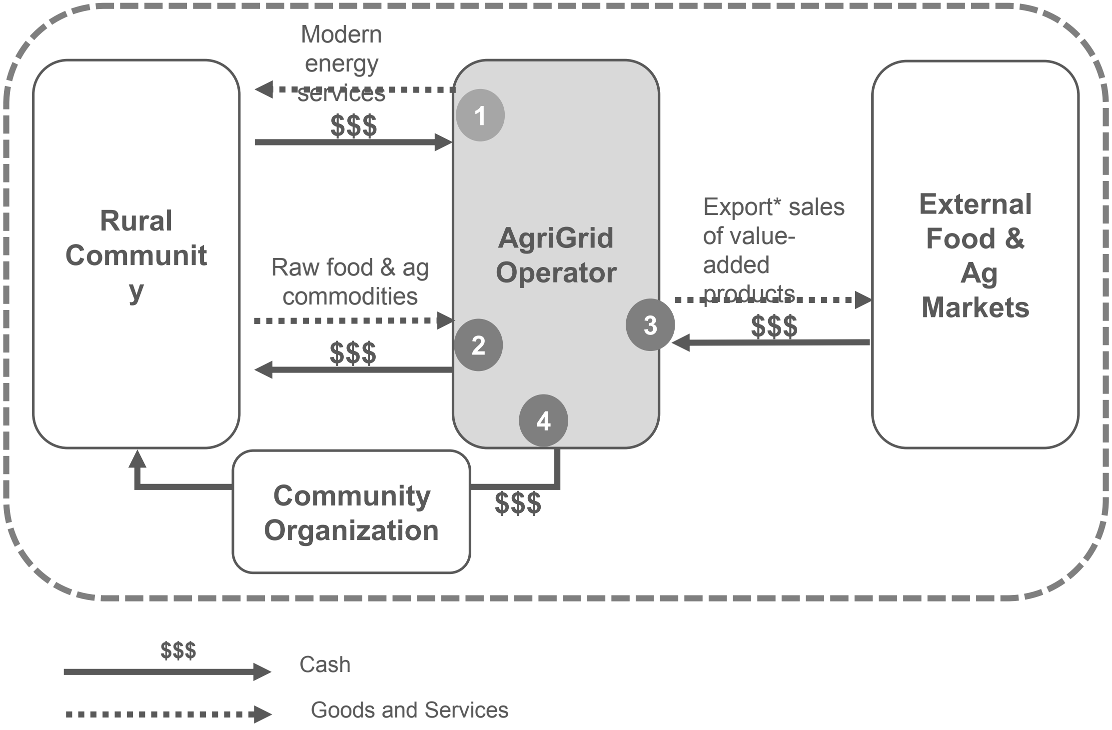
INTRODUCING AGRIGRID

A business model concept integrating agribusiness with mini-grid electrification

© ANKA Madagascar

AgriGrid businesses export* value-added products to external markets while also selling modern energy services



1. *AgriGrid Operator installs and operates mini-grid and sells energy services to community.*
2. *AgriGrid Operator develops and agricultural strategy, and purchases raw food & ag products from community.*
3. *AgriGrid Operator refines raw food & ag products and sells value-added food & ag products to external markets.*
4. *AgriGrid Operator and Community Organization manage a profit-sharing arrangement with the community.*

* "Export" refers to the sale of commodities produced in rural communities to *any* external market, including domestic urban markets.

Several levers are used to create economic value and increase export revenue in electrified villages

1. *Increased crop yield, diversity, intensity*
2. *Extra harvest season for income smoothing*
3. *Production of modern, commercial grade food and agricultural products*
4. *Reduction in losses, pricing power, access to new markets*
5. *Reduction in losses, entrance to formal sector, access to new markets*
6. *Reduction in losses, entrance to formal sector, access to new markets*
7. *Institutional infrastructure for convening, training, revenue sharing*
8. *Business analytics for decisions, optimization, reporting*
9. *Agricultural sales, technical partners, marketing, capital, legitimacy*

A set of food and agricultural operations are added to the mini-grid development lifecycle

	Pre-construction		Construction	Operations	
Modern Mini-Grid Operations	**Mini-Grid Site Assessment** Technical, social, economic assessment	**Community Engagement** Introduction to modern energy services, community buy-in	**Mini-Grid Design / Installation** Design and construction of generation, storage, distribution, metering	**Energy Services Sales** Sale of energy, appliances, equipment, other goods and services	**Ongoing Support** Technical and commercial support
Additional Operations Under an AgriGrid Model	**Food & Agri Opportunity Definition** Definition of key food & agri value creation opportunities	**Agri Community Organization** Development of organization for convening, training, and revenue sharing among farmers	**Agri Design / Installation** Installation of agri equipment – e.g. irrigation, processing equipment, storage, packing facilities	**Agri Purchasing** Purchase of raw food and agri commodities from community for value addition	**Agri Revenue Sharing** Profit sharing with community organization and farmers
	Agri Site Assessment Assessment of key value chains, market demand, potential off-takers/buyers	**Agri Strategy & Partnerships** Development of commercial agribusiness strategy and securing of key technical and commercial partners	**Agri Training** Training of farmers and micro-enterprises as required	**Agri Processing** Value addition at own or partner's facility **Agri Sales** Sale of value-added food & agri products to external markets	

3

WHY AGRIGRID?

Targeting rural prosperity and strengthening mini-grid business models

Food and agriculture is a major potential source of wealth creation for rural areas

60% of arable land is in Africa[1]

Only 4% of arable land in Sub-Saharan Africa is irrigated[2]

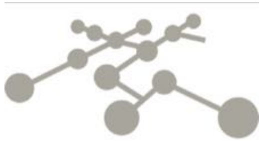
Average fertilizer use in Africa is 17kg per hectare of arable land, compared with a global average of 135kg[3]

Agribusiness in Africa is a $1 trillion opportunity[4]

Sources:

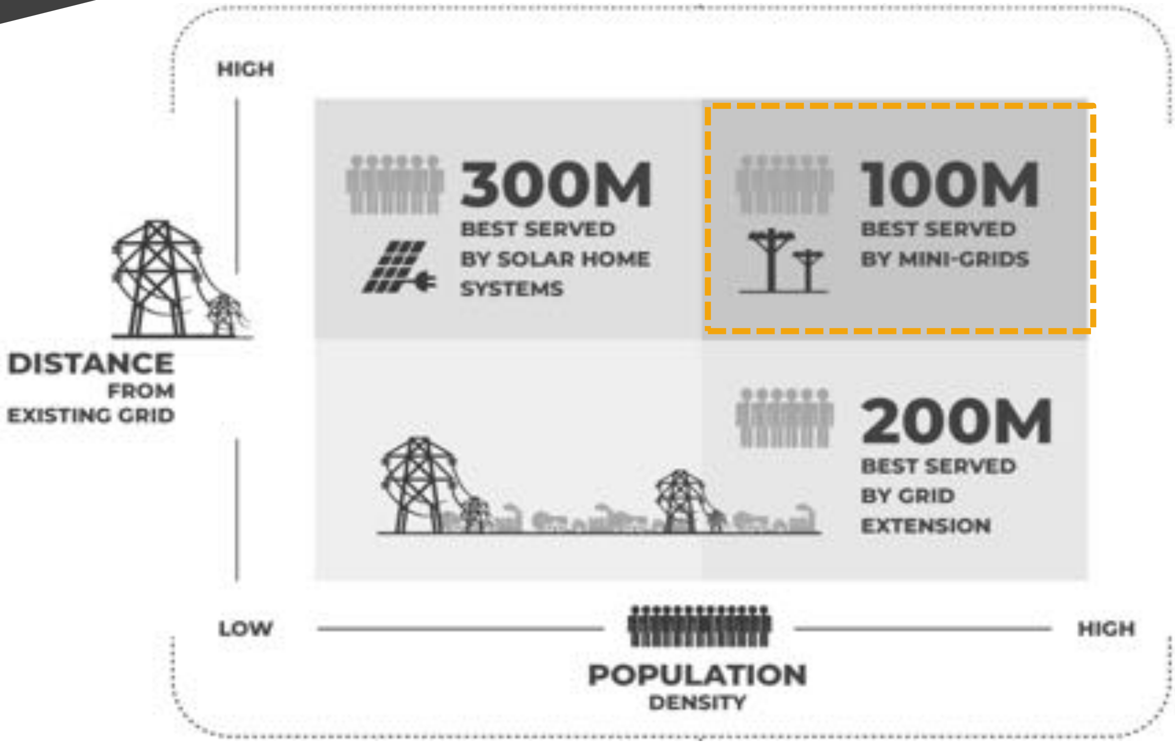
1 https://www.growafrica.com/news/60-arable-land-africa-and-it-has-billions-investment-potential
2 http://www.ifpri.org/blog/irrigating-africa
3 https://gro-intelligence.com/insights/articles/fertilizers-in-sub-saharan-africa
4 https://www.afdb.org/en/news-and-events/africa-agribusiness-a-us-1-trillion-business-by-2030-18678

Rural communities in Africa are often marginalized and excluded from agricultural wealth


	Rural Areas	**Domestic Food and Agriculture Networks**	**Urban Areas**
Characteristics	• Low income, agrarian communities • Limited access to information and knowledge of best practices • Limited access to inputs • Limited access to finance • Limited access to markets • Off-grid with limited infrastructure	• Strong presence of informal, opportunistic and exploitative operators • Inefficient operations with limited incentive to modernize or optimize • Often simple and low CAPEX trading businesses	• Expanding populations • Emerging, aspirational middle class • Increasing purchasing power • Increasing demand for quality food and beverages
Status quo	At the mercy of informal traders and middlemen	Inefficient systems with unrealized technical potential and large losses	Growing demand met by cost competitive food imports
Long-term outlook	Likely to remain economically disenfranchised and fragile without enhanced farmer protection	Likely to remain fragmented without major investments by formal actors	Likely to continue to favor imports over costly or low quality domestic products

Mini-grids are an important electrification solution for rural Africa but can be challenging investments

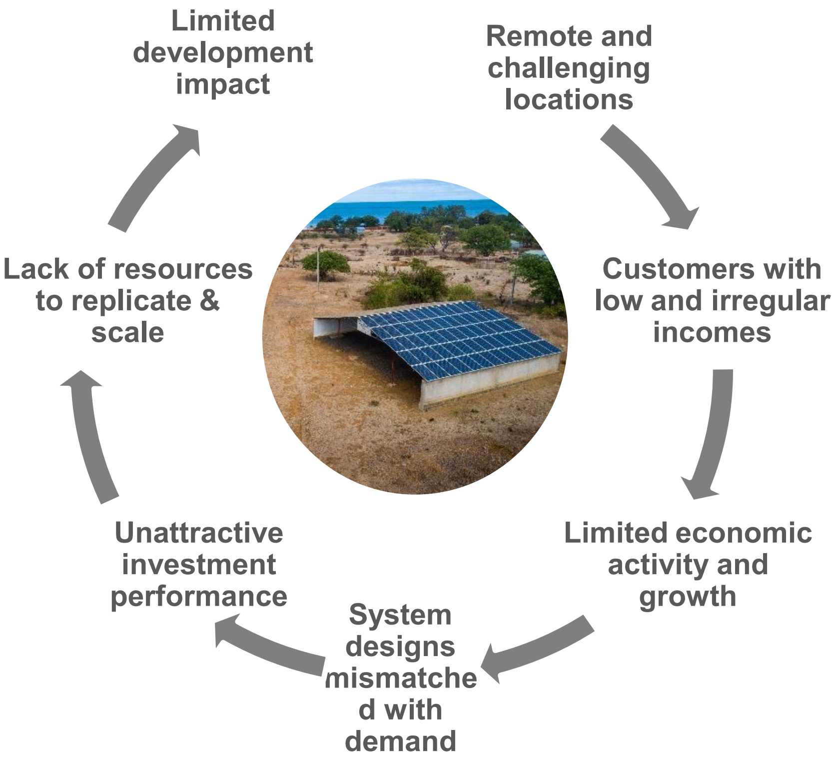


Source: CrossBoundary Energy Access

Modern Mini-Grid Investments in Africa

- High Average Investment Per User
- Low Average Revenue Per User
- Uncertainty in load and revenue forecasting
- Limited economic activity precludes demand growth
- OPEX floor reduces site profitability
- Uncertain interactions with utilities and national planning
- Uncertain and dynamic regulatory environments
- Dynamic subsidy and capital environments
- High WACC reflecting several sources of investment risk

Site-level difficulties have limited* the scaling and impact of mini-grids in Africa to date

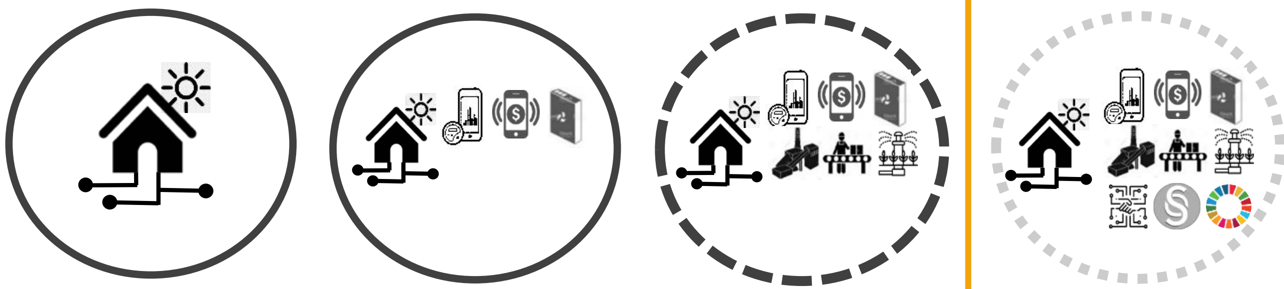


- Mini-grids are deployed in low-income communities with irregular cashflows
- The sizing of generation and storage is challenging due to seasonality and uncertainty in load forecasting
- Tariff designs require experimentation to test acceptance with price-sensitive communities
- Long-term growth in energy demand is difficult to forecast and rarely matches estimates
- Site-level investment performance remains poor, making it difficult for developers to access additional resources to scale

*Note: The scope of this note is limited to site-level economics. It does not discuss broader but also critical challenges affecting mini-grids such as: licensing, regulation, financing/subsidies, and other aspects of the investment climate.

Fortunately, standardization is enabling commercial experimentation: “Mini-Grids 3.0” and beyond

AgriGrid



	Mini-grid 1.0	Mini-grid 2.0	Mini-grid 3.0	Mini-grid 4.0
	Serving Rural Customers	*Building Smart Businesses*	*Accelerating Investment*	*Enabling Digital Economies*
TECHNOLOGY	Simple demonstrations	Smart tariffs, remote O&M	Consolidation of smart technologies	Digital integrations
VENTURE	Experimentation in market segments, B2B/B2C customer mixes, tariff designs, OPEX reductions, bundling/financing, corporate structures			Nexus/cross-sector innovation between mobility, water, food & agriculture, ICT
MARKET	Identification of investment climate requirements	Global, regional, and country market readiness, new financing facilities, public subsidies programs, market acceleration initiatives		Market standardization / maturation

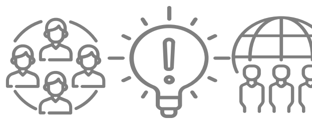
Mini-grid companies bring valuable resources and capabilities that can be leveraged to ease constraints in agribusiness

Relevant strengths of mini-grid companies

Commercial and technical expertise | National and international recognition | Visibility and credibility | Business networks and partners | Smart technologies | Ability and ambition to operate at scale | Formal business practices | Social impact-orientation

African agricultural commodity value chains face common constraints[1]

Under-Performing Value chains	Insufficient utilization of inputs and mechanize-tion	Limited reach of to boost on farm production	Poorly organized post aggregation and transport	Inconsistent capacity for effective value addition	Poorly developed market linkages trade corridors
Insufficient Infrastructure	Insufficient transport, energy, water and others hard infrastructure leading to uncompetitive cost structures		Underdeveloped soft infrastructure aging smallholder farmers and lack skills commercial agriculture and agro-allied industries		
Limited to agriculture finance	Real and perceived risk limiting private sector investment	High service cost due to small deal sizes, lack of data, and low capacity in agriculture lending		Limited market attractiveness relative to perceived higher returns outside of the agriculture sector	



Source:
[1] https://www.afdb.org/fileadmin/uploads/afdb/Documents/Generic-Documents/Feed_Africa-Strategy_for_Agricultural_Transformation_in_Africa_2016-2025.pdf

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African agricultural commodity value chains face common constraints[1]

Adverse agri-business environment	Unfavorable access and incentives limiting trade and capacity to produce high-quality products	Ineffective sector regulation creating long lead times for new technologies inconsistent trade policies	Unsupportive business enabling environment restricting land tenure and general ease of doing business
Limited inclusivity, sustainability and nutrition	Insufficient inclusivity of women and youth in agriculture development	Limited incentives to ensure sustainability and climate-resilient practices.	Limited access and affordability of commodities with high nutrition levels

Source:
[1] https://www.afdb.org/fileadmin/uploads/afdb/Documents/Generic-Documents/Feed_Africa-Strategy_for_Agricultural_Transformation_in_Africa_2016-2025.pdf

Mini-grid companies navigate several unknowns when identifying, assessing, and designing new sites

Who to connect to the grid?

- What mix of anchor, institutional, micro-enterprise, and household customers to connect?
- Who is too far from the mini-grid?
- Who is best served by an SHS?

How to design tariffs and forecast long-term pricing?

- How to design a tariff structure for differing customer segments?
- How will communities and customer behavior change once over time?
- How will communities react to tariff changes?

How to manage seasonality?

- How can we increase demand for electricity over the long-term?
- How can we manage low consumption during low-income seasons?
- How can we smooth Abilities to Pay (ATP) and/or energy consumption throughout the year?

How to size and time CAPEX?

- How much generation and storage capacity to install?
- How much capacity to install now vs. later?
- How to ensure that electrical equipment and appliances are available in the community?

By creating rural wealth, AgriGrid operators mitigate key mini-grid investment risks

Who to connect to the grid?

- By providing access to market for agricultural commodities, a greater number of households will be able to afford connection fees and electricity purchases.
- Some households will remain untenable for mini-grid connection due to their location.

How to design tariffs and forecast long-term pricing?

- Greater disposable income provides certainty around increased household demand for electricity.
- Commercial loads from agricultural infrastructure can be accurately forecasted during business planning.
- The existence of a community organization that is connected to agriculture and energy operations can mitigate social risks.

How to manage seasonality?

- Greater income increases household resilience and the ability to save during low-income seasons.
- AgriGrid operations can be designed with multiple food & ag value chains to smooth incomes and load year-round.

How to size and time CAPEX?

- Increased incomes enables greater certainty in ability to pay for electricity.
- Installing a large commercial processing facility to support a viable agribusiness decreases error margins in capacity planning.
- Providing market linkages ensures that equipment and appliances are paid off.

The model alleviates challenges in crop productivity, rural incomes, energy access, and food systems

	Modern Mini-Grid	*AgriGrid*
	• Low agricultural productivity • Low and irregular household incomes • Limited ATP* for energy services • Limited growth in energy demand • Economically fragile communities • Financially fragile mini-grid companies	• Optimized agricultural productivity • Increased and smoothened incomes • Greater disposable income for energy consumption • Economically growing communities • Financially valuable agribusiness companies
	• Informal, exploitative, inefficient agribusiness industry	• Modern, efficient, and commercial-scale agribusiness
	• Unmet consumer demand for food • Net food importer • Government food subsidies	• Consumption of domestic products • Net food exporter • Government FX revenue

While the AgriGrid model may create long-term value, operational risks also increase

STRENGTHS

- Increased household incomes in rural areas
- Increased household energy consumption
- Improved load forecasting
- Decreased effects of seasonality
- Increased development impact
- Improved investment performance
- Greater trust with communities
- Increased national economic benefits

WEAKNESSES

- Need for agribusiness and mini-grid expertise
- Increased CAPEX and OPEX requirement
- Complex, site-specific project designs and models
- Multi-party/partner commercial risks
- New regulatory risks (food and agriculture)
- Inter-/intra-company tradeoffs

OPPORTUNITIES

- High value international export opportunities
- Multi-value chain product strategies
- More attractive financing terms and envelopes
- Transformation of local communities
- Creation of industrial clusters
- Integration with national energy, food, and agro-industrial investment planning
- Leveraging food, agriculture, and nutrition resources for energy access aims

THREATS

- Competitive pressures in food and ag markets
- Dependency on seasonal commodities
- Climate risks: floods, pests, crop disease, drought
- Pricing risks of agricultural commodities
- Community risks of profit sharing models
- Risk of disenfranchising existing traders
- Challenging to secure partners due to complexity

4

CASE STUDY

Assessing an AgriGrid opportunity in rural Madagascar

© ANKA Madagascar

Approach: Exploring an AgriGrid at “MadaSite”

Market analysis

- We assessed domestic consumer demand in Madagascar for food and agriculture products only. This was to bound the analysis and avoid assessing high-value export opportunities which could be endless and uncertain.
- We used national food import data as a proxy for domestic consumer demand.

Site selection

- ANKA Madagascar has a large mini-grid site pipeline at various stages. We combined existing site data with the outcomes of the national food & agriculture market analysis.
- We medium-listed 8 sites and shortlisted 3 potential sites for rapid scans.
- We collected food & agricultural data from the 3 shortlisted sites and selected one (“MadaSite”) for a more detailed, deep dive analysis.

Base case

- We used data from an existing ANKA Madagascar feasibility assessment to create a “Base Case” for MadaSite.
- The assessment included specifications for the mini-grid design, investment sizing, financial projections, and impact projections.

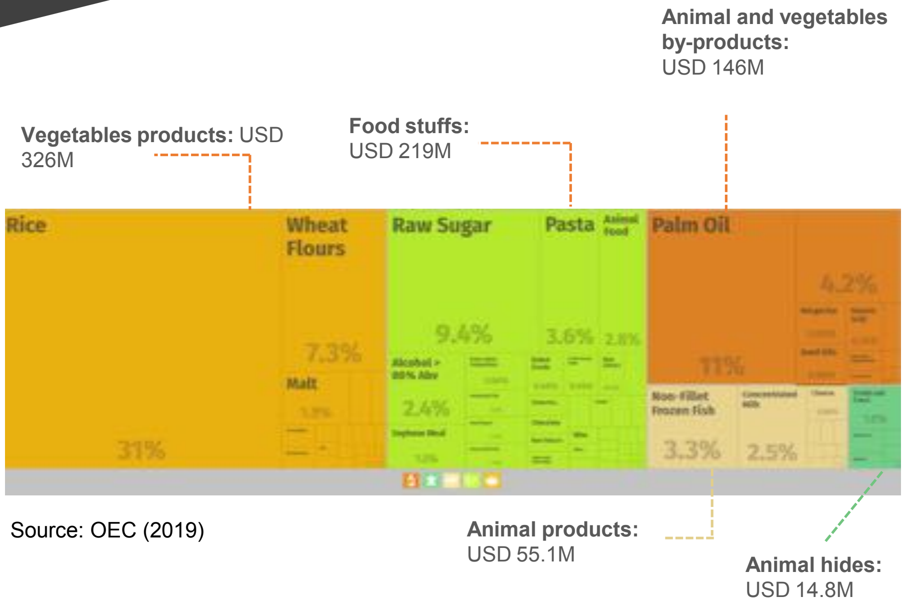
AgriGrid case

- We assessed food & agriculture value chains in MadaSite to identify opportunities for value creation/addition and household income growth.
- We prototyped an AgriGrid business model, researched key technical and commercial needs, and collected additional site data as required.
- We modeled an “AgriGrid Case” at a pre-feasibility level of assessment.

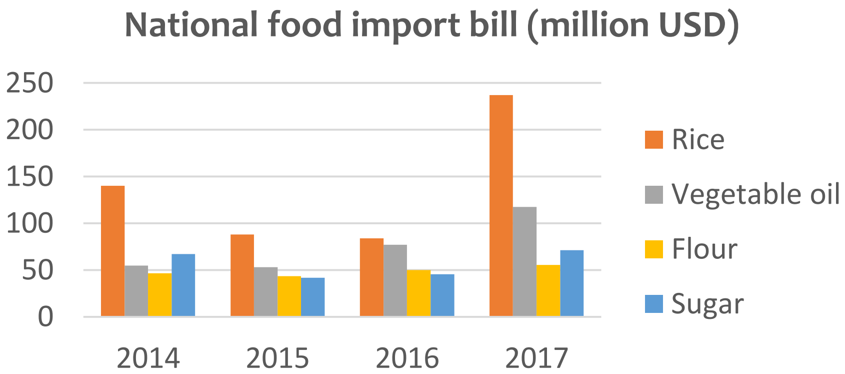
Case analysis

- We compared the “Base” and “AgriGrid” cases across financial, economic, and impact KPIs.
- We assessed whether the investment opportunity is attractive enough to take forward.

Madagascar imports USD 760 million of food and animal products annually – roughly 6% of GDP1



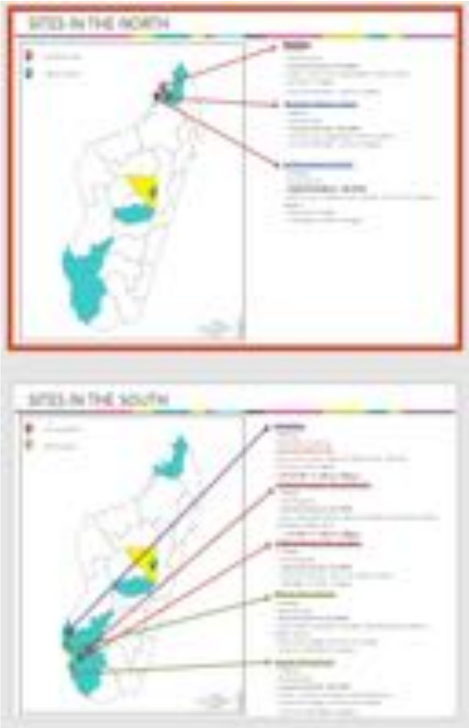
Source: OEC (2019)



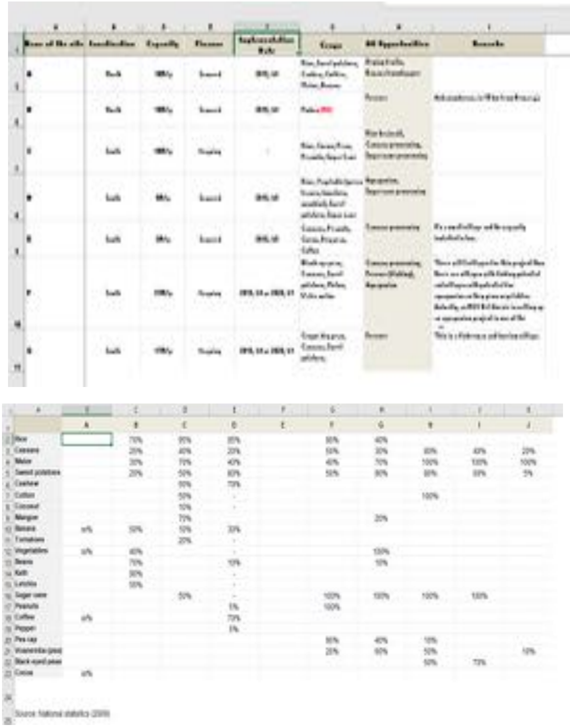
Source: OEC (2019)

Site Selection: Exploring fit with existing sites

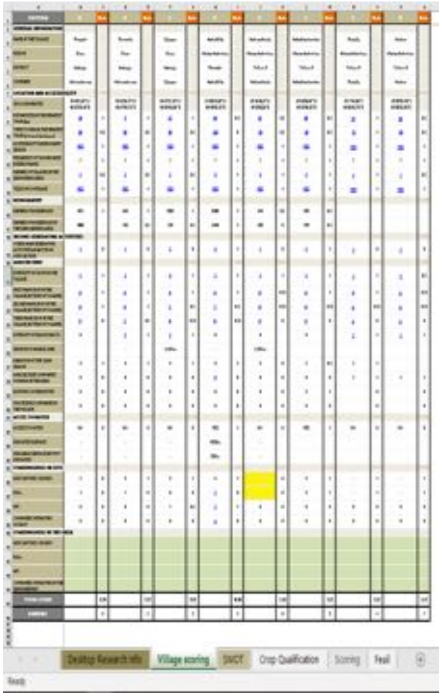
Potential Pipeline Sites



Basic Site Analysis



Initial Site Scoring



Note: Site names are anonymous and image resolution is low for data confidentiality.

Site Selection: 3 sites shortlisted sites for Rapid Scans

Site 1

1,000 Households
07 Schools
09 Churches
01 Clinic
20 SMEs

Mini-grid specifications

325 kW solar PV
110 kVA diesel
900 connections

Food & Agriculture

Carrots; cabbage; potato; tomato; ginger; khat; poultry

Site 2

1,080 Households
03 Schools
08 Churches
01 Clinic
10 SMEs

Mini-grid specifications

176 kW solar PV
110kVA diesel
700 connections

Food & Agriculture

Cocoa; rice; sweet potato

Site 3

1,262 Households
05 Schools
06 Churches
01 Clinic
15 SMEs

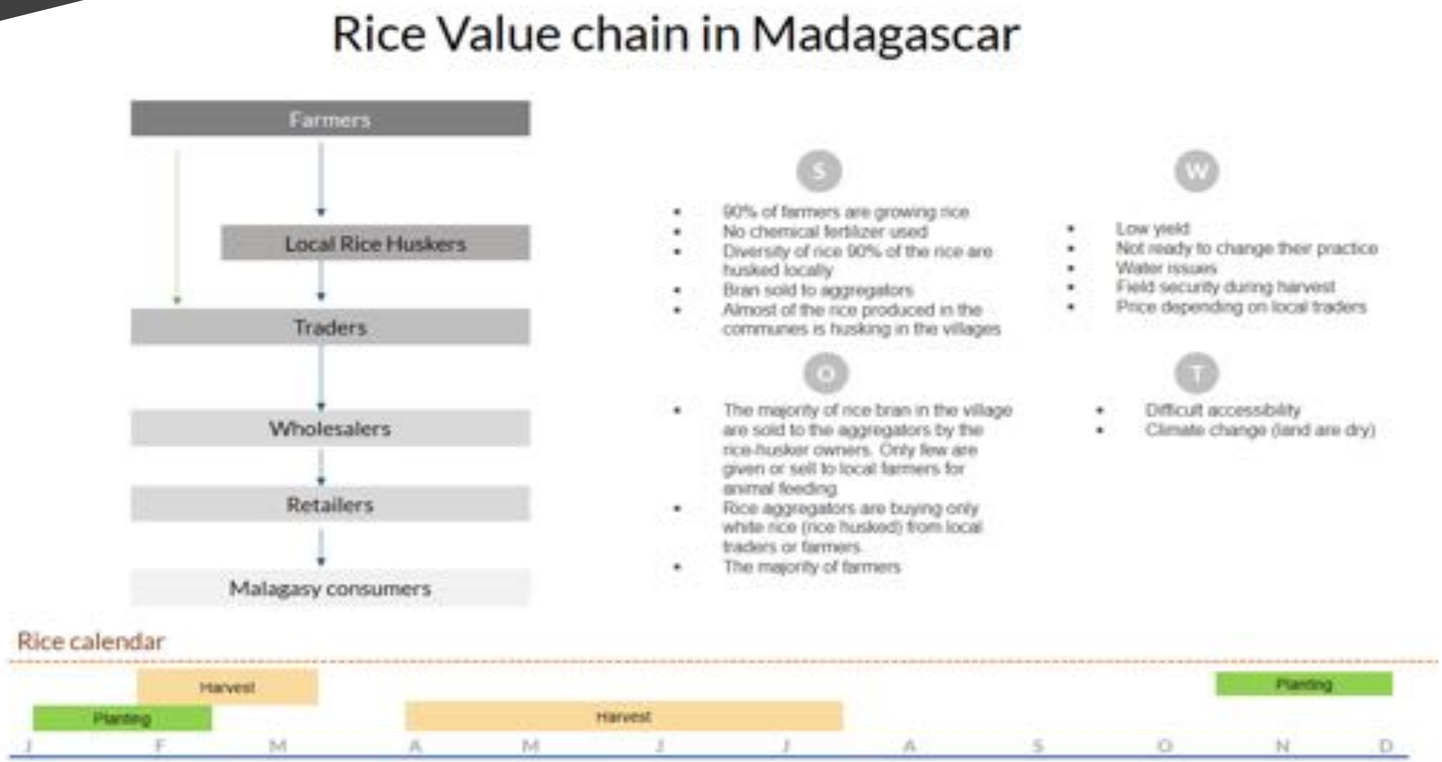
Mini-grid specifications

195 kW solar PV
110 kVA diesel
800 connections

Food & Agriculture

Rice; tomato; banana; mango; sugarcane

Quick Scan Results: Food & ag value chain data



- For each of the 3 shortlisted sites, our field team gathered data on existing food & agriculture activities
- We coupled this data with pre-existing site feasibility assessments
- We looked at other generic factors - such as road access, presence of commercial ag players, proximity to demand centers, and more – to select the site for a deeper dive

Note: Ideally, we would have assessed a cluster of sites to achieve economies of scale. We considered this out of scope for this R&D project due to limited time and budget.

Site Selection: “MadaSite”

General Site Information

1262 Households

05 Schools

06 Churches

02 Clinics

15 Rice huskers

Poor network coverage

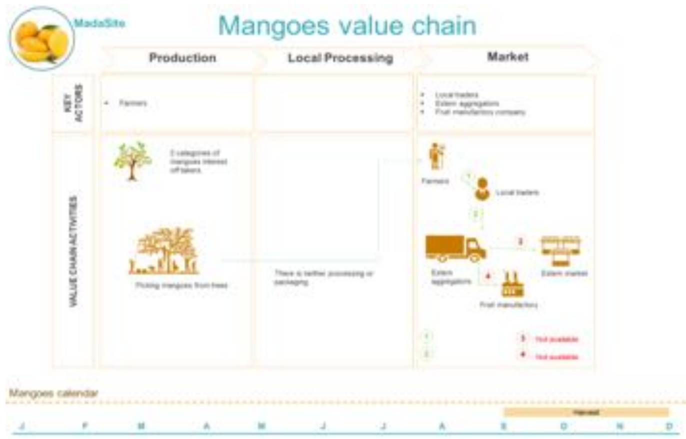
12 km from paved road

- Closest town: 13 km
- Head of region: 145 km
- Capital: 990 km

Daily bus and rickshaws to closets town

Nearest grid: 13 km

Agricultural Information



Mini-Grid Specifications

195 kW Solar PV
110 kVA Diesel
252 kWh Li-ion storage
14,5 km LV network
800 connections
- 780 1-Phase connections
- 20 3-Phase connections

Base Case: A modern mini-grid at MadaSite

A 192 kWp Solar PV/Diesel hybrid project at MadaSite performs as a conventional modern mini-grid

Customers

Number of phase 1 users	#	983
Number of phase 3 users	#	12

Total Generation Assets

Solar PV incl. mounting system	kWp	192
Diesel generators	kVA	140
Battery	kWh	252
PV inverter	kVA	170

Total Distribution Assets

LV distribution grid	km	14,2
MV distribution grid	km	–

Financed with

Funding

Sources USD		Cash
Grant	USD	543.089
Village Contribution	USD	-
Senior Debt	USD	243.636
Equity	USD	131.188
Total	USD	917.913

Translating into

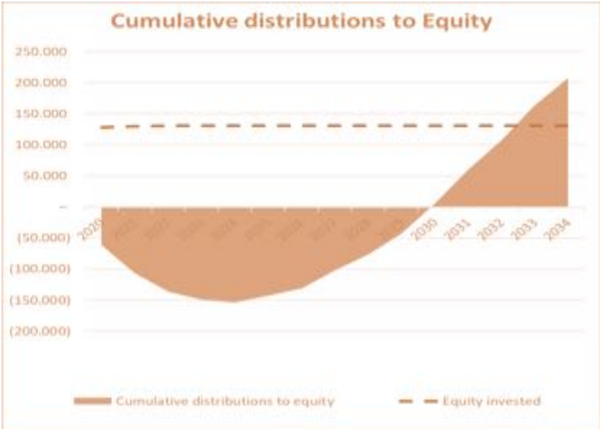
Investment and Project Performance*

Returns

Forecast period	years	25

Equity		agri-grid
Equity IRR (US$ based)	%	17,33%
Project IRR (MGA based)	%	19,5%
Project NPV	USD	227.086
Payback (yrs)	years	10

Return to equity



*Capital structure = 55% grant, 15% equity, 30% debt; equity IRR = 12%, WACC = 12.5%.

AgriGrid case: Food & ag analysis at MadaSite

The main and existing agricultural value chains include rice, tomato, banana, mango, and sugarcane.

	Market potential	Social impact	Scale and replicability	Seasonality
Rice	•••	•••	•••	••
Banana	••	•••	•••	••
Sugar cane	••	••	••	•
Tomato	••	•	••	•
Mango	••	••	•	•

High potential

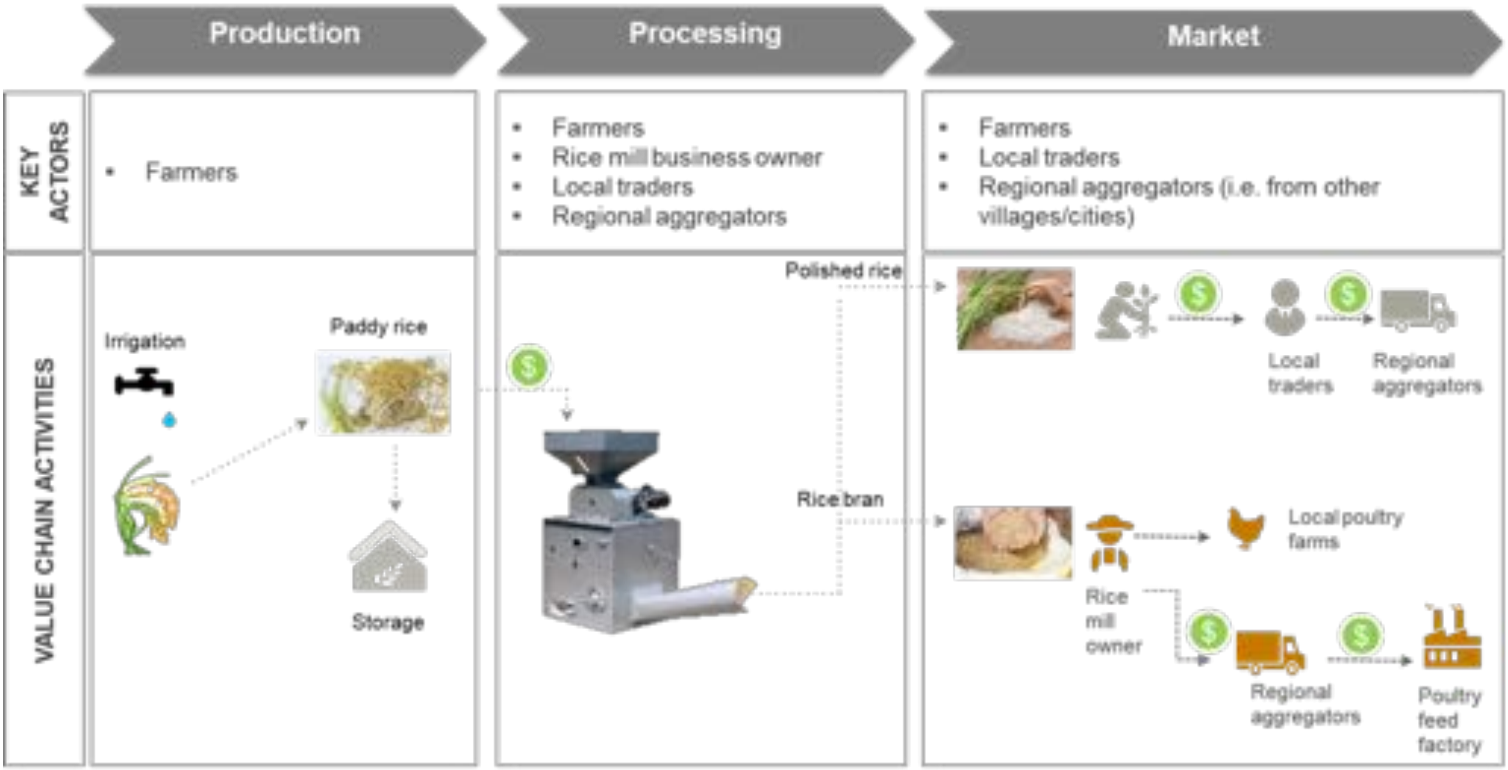
- 90% of farmers in the village grow rice
- There are 2 harvest seasons, smoothing incomes
- Rice is the main staple crop in the country, so the opportunity is highly scalable to other sites
- Rice millers want electricity to replace diesel

- Many other sites have high banana production
- Bananas can be processed into juice or dried fruits
- Bananas grow almost year-round

- There is a sugar company near the site
- Around 50% of the farmers grow sugarcane
- Few areas in the country produce sugarcane

Result:
We selected the rice value chain as the lead value creating opportunity in MadaSite. Rice is grown throughout the country however there is minimal value addition in rice value chains. Madagascar imports USD 118 million of cooking oil, for which domestically produced **Rice Bran Oil (RBO)** can be a competitive substitute.

AgriGrid case: Food & ag analysis at MadaSite



AgriGrid Case: Producing RBO at MadaSite on a rather small scale with max. 20 MT per day during high season

Number of local rice huskers	#	29
Average rice bran processed during HIGH SEASON per husker	MT p.m.	20,0
Average rice bran processed during LOW SEASON per husker	MT p.m.	7,0
Average volume of rice bran per husker	MT p.a.	123,0
TOTAL rice bran production	MT p.a.	3567,0
Purchasing price from rice dehuskers	MGA/MT	300.000
Rice husker inclusion rate	%	
Total annual rice bran yield	MT p.a.	
Losses and wastage	%	10,0%
Net annual production volume	MT p.a.	
Rice bran oil content	%	20,0%
Rice bran oil volume p.a.	MT p.a.	**642,1**

Annual sales of more than 1 billion MGA p.a. both to local shops and to wholesalers (equivalent to USD 280k)

AgriGrid Case: Assumptions

Market

- Households would adopt RBO at a competitive price
- Household cooking oil consumption of 2 liters/month
- Sales territories and the storage facility sized such that RBO sales were possible year-round

Business Design

- Mini-grid and RBO investments are shared by one entity
- O&M of mini-grid and RBO assets provided by one entity
- Rice bran catchment area limited to electrified mills (29)
- RBO factory receives free electricity (i.e. self-consumption)
- RBO sold to retailers *outside of MadaSite*
- RBO profits are shared 50/50 with community association
- Community association allocates RBO profit share in cash (i.e. not in-kind)
- Households maintain % energy expenditure

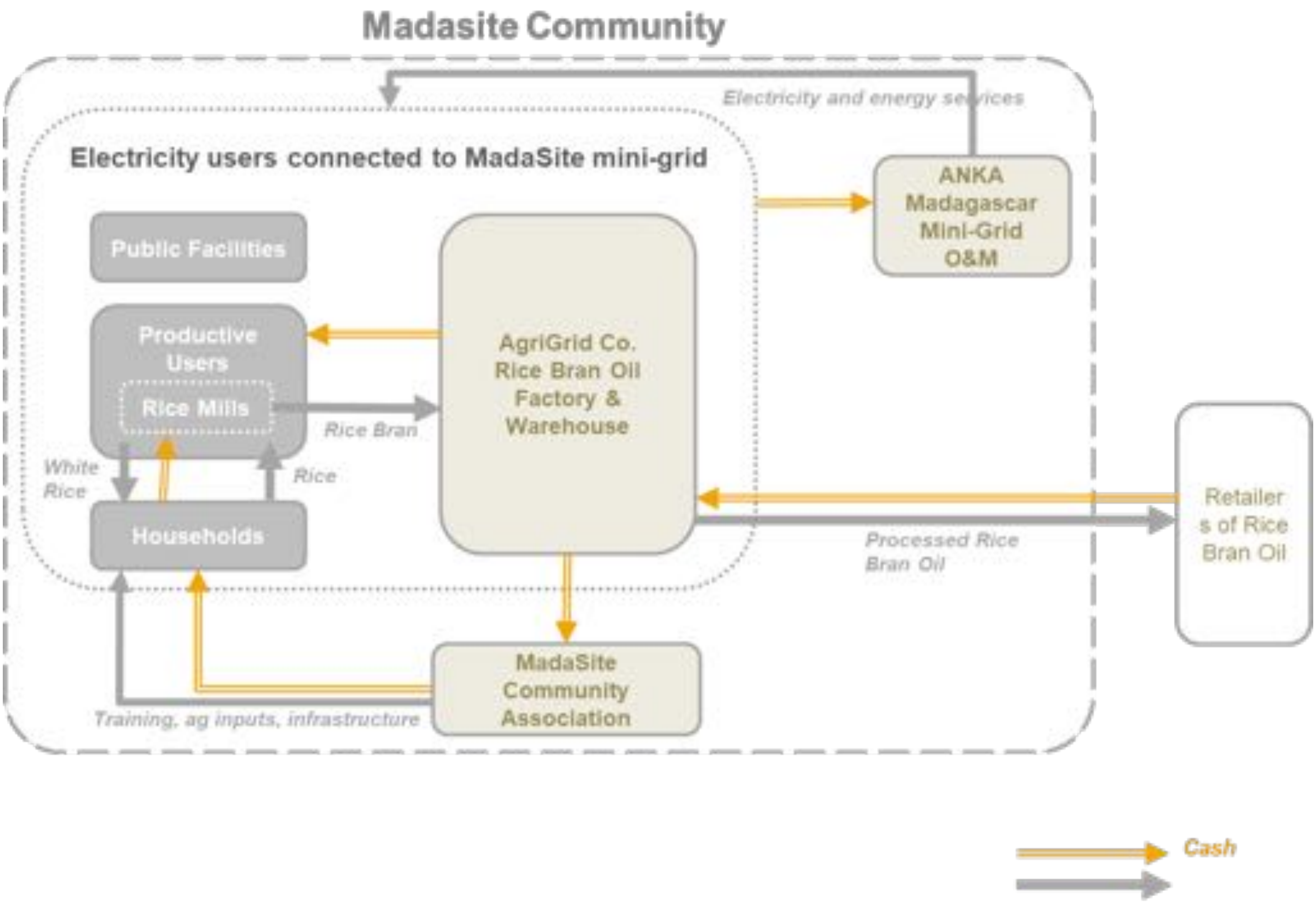
Energy

- System size not affected – simply less excess capacity
- Distribution network design not affected -lower number of household connections than Base Case
- Increase in household energy consumption ~ increase in disposable income

Rice Bran Oil

- 50% of existing bran would be available for purchase
- No bran storage, but storage for RBO
- Operations of 300 days/year
- 10% loss between bran supply and produced RBO

AgriGrid Case: Prototype project design



AgriGrid Case I: Small-scale mini-grid + RBO sales don't lead to improved financial performance

Unchanged number of productive users (apart from rice bran oil processing plant as internal consumption) but increased power production capacity

Customers

Number of phase 1 users	#	983
Number of phase 3 users	#	13

Total Generation Assets

Solar PV incl. mounting system	kWp	280
Diesel generators	kVA	230
Battery	kWh	340
PV inverter	kVA	250

Total Distribution Assets

LV distribution grid	km	14,2
MV distribution grid	km	–

Financed with

Funding

Sources USD		Cash
Grant	USD	885.238
Village Contribution	USD	-
Senior Debt	USD	400.137
Equity	USD	215.458
Total	USD	1.500.833

Translating into

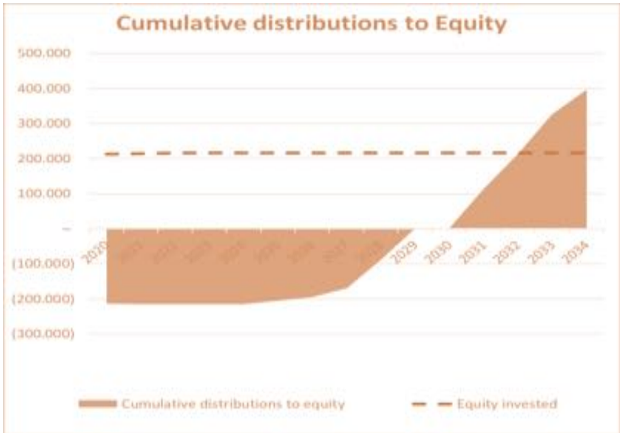
Investment and Project Performance*

Returns

Forecast period	years	25

Equity		agri-grid
Equity IRR (US$ based)	%	14,40%
Project IRR (MGA based)	%	17,3%
Project NPV	USD	228.438
Payback (yrs)	years	10

Return to equity



*Capital structure = 50% grant, 25% equity, 25% debt; WACC = 6%

AgriGrid Case II: Going to scale turns the page

Unchanged number of productive users (apart from rice bran oil processing plant as internal consumption) but increased power production capacity

Customers

Number of phase 1 users	#	983
Number of phase 3 users	#	13

Total Generation Assets

Solar PV incl. mounting system	kWp	790
Diesel generators	kVA	650
Battery	kWh	340
PV inverter	kVA	700

Total Distribution Assets

LV distribution grid	km	14,2
MV distribution grid	km	–

Financed with

Funding

Sources USD		Cash
Grant	USD	3.701.417
Village Contribution	USD	-
Senior Debt	USD	1.420.588
Equity	USD	764.932
Total	USD	5.886.937

Translating into

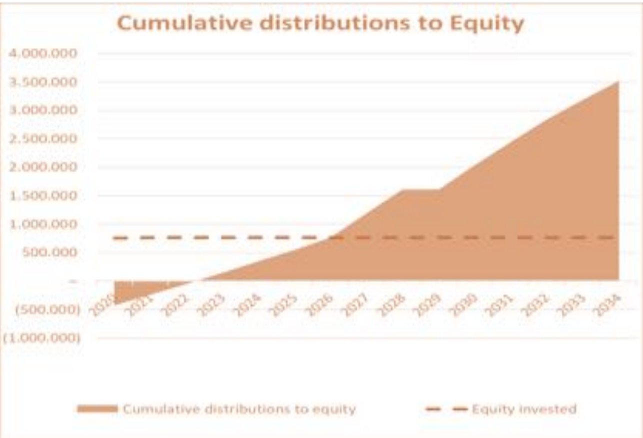
Investment and Project Performance*

Returns

Forecast period	years	25

Equity		mini-grid only
Equity IRR (US$ based)	%	34,53%
Project IRR (MGA based)	%	27,2%
Project NPV	USD	2.085.774
Payback (yrs)	years	5

Return to equity



*Capital structure = 50% grant, 25% equity, 25% debt; WACC = 6%

Limitations of the AgriGrid Case analysis

Agricultural Modelling	• Other, higher potential market opportunities for increasing "export revenue" likely exist. We selected the cooking oil market to illustrate here due to established demand and clear information on retail pricing. • There are several additional options for agricultural value creation in other value chains. We limited our analysis to new product development based on existing value chains.
RBO Production and Retail Marketing	• We assumed that Malagasy households would purchase RBO as a cooking oil substitute. • RBO is not a simple oil; it involves complex processing which we simplified in our analysis. • There are several retail options which we brainstormed but did not explore. We simplified retail operations by indicating a retail price competitive with existing oils and used an industry standard profit margin.
Energy System Modelling	• We did not materially adjust the mini-grid design between the two cases. This is likely not realistic. • Since we did not adjust energy system dimensions, we instead estimated trade-offs for # connections, consumption, and revenue.
Community and Household Modelling	• We assumed households and rice millers would willingly sell rice bran to the AgriGrid operator in exchange for profit-sharing. • We assumed that electricity consumption would rise with increased incomes.

Comparing a mini-grid vs. AgriGrid with different sizes at MadaSite

The proposed AgriGrid project design increases development impact and investment performance but only at large scale

Performance		Mini-grid case	Small AG case	Large AG case	Deviation L-S
Average EBIT margin	%	19.1	12.1	**12.6**	0.5
Equity IRR	%	17.3	14.4	**34.5**	20.1
Equity NPV	USD	101,793	67,299	**1,364,551**	1,297,252
Equity payback	years	10	10	**5**	-5
Cumulated flow to equity	USD	1,036,323	1,240,415	**6,364,811**	5,144,396
Funding		**Mini-grid case**	**Small AG case**	**Large AG case**	**Deviation L-S**
Grants for assets	USD	543,089	885,238	**3,701,417**	2,816,179
Grants for first loss	USD	83,727	130,901	**0**	0
Village contribution	USD	0	0	**0**	0
Senior debt	USD	243,636	400,137	**1,420,588**	1,020,451
Equity	USD	131,188	215,458	**764,932**	549,474
Total	USD	1,001,640	1,631,734	**5,886,937**	4,255,203

Conclusions and the way forward

- **We decided not to continue with a full feasibility assessment of the RBO opportunity.** While attractive, RBO production appears technically complex, requiring sophisticated supply chains and high volumes.

- Were we to continue with the RBO value chain**, a full feasibility study would include:** consumer taste testing of RBO, an assessment of food and ag regulations, detailed sales channel research, deeper technical and operations research, and deeper supply chain research and modeling.

- **We would require an RBO technical expert and community development expert** to complete a full feasibility assessment.

- **We would further assess the governance model.** A joint venture or partnership may be preferable to a fully integrated entity.

- **Going to scale with the RBO value chain will create funding challenges.**

- Instead, we investigate other value chains that are **less complex, less challenging in terms of investment and operationalization, and more easily replicable.** A pilot is being developed for commissioning in 2021.

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